Thi_Qar University Journal for Engineering Sciences
Vol. 9 No.1 (2018)
ISSN 2 075– 9746
Available at http://jeng.utq.edu.iq
engjrnal@jeng.utq.edu.iq

Modeling of Structural Human Dynamic Response

Kadim Karim Mohsen AlTurshan
Mechanical Engineering Department College of engineering / Thi-Qar University

Abstract
Study the simulation of human response during the moving on various roads and represent the human body as discrete masses, springs and damper system. Assessment of vibration condition impacts of human in the perspective of the unfavorable safety impact was introduced. Be that as it may, it is important to do the comprehension the impact of vibration to human body to look at their legitimacy and to plan for the future vision. This paper demonstrates the point of interest estimation of human reaction to vibration, and the displaying of the human body for the appraisal of the vibration hazard. The vibration transmissibility from the beginning of the human body amid the introduction to vertical excitation. The modular parameters are resolved with a specific end goal to comprehend the standards normal modes.

The model shows that human reaction relying upon vibration condition. The presentation of the present model to vibration stacking is contrasted and the examination information and a practical contract are found. The presentation of human determination demonstrates a geometric depiction of the parameters which influence the unwavering quality of a basic segment subjected to vibration stacking. The control of the investigative model and the recreation examination in the present work demonstrating the distinctive mode shapes, Eigen values/vectors, and the burdens brought about by such vibration stacking that can lead. The model is introduced to manage the human agreeable and to locate a fitting blend between human reaction and vibration condition.

Keywords **Human excitation, Transmissibility, Simulation, Biodynamic responses.**

1. Introduction

Consistently individuals are presented to vibration in numerous standard exercises, for example, riding in vehicles, working with vibrating machines, utilizing force instruments, and so forth. Serious or long haul presentation to vibration can influence solace, security and wellbeing of persons uncovered. Vibration is a typical figure the working environment, it is perceived as an occupation wellbeing danger and ought to be dealt with as peril such that it is controlled, wiped out or minimized [1].

At the point when going in transport, situated individuals are presented to vibration from the seat and the backrest. Research center trial investigations of vibration inconvenience have generally been led without a backrest or with an inflexible vertical backrest. In static situations a backrest gives more bolster and more solace when it is slanted, however backrest slant may be relied upon to impact the vibration transmitted to the body and the distress created by vibration amid travel. [2].

Normal vibrations we can experience come predominantly from the uneven street, changing of velocity, sound created when a sudden stop of the transport and train, and so forth, and these vibrations can bring about harms to us. Diverse vibrations can bring about distinctive levels of uncomfortable feeling on guys and females. Some past studies have explored how vibration influenced functioning proficiency, wellbeing and wellbeing .However, couple of studies examined the sexual orientation contrasts, if any, in the human reaction under diverse vibration frequencies [3].

Specialists extraordinarily varied about the recognizable proof of regular frequencies of the hand-arm frameworks in biodynamic reactions. Which study displays a preparatory limited component (FE) model of the hand-arm framework to focus the common frequencies and mode states of distinctive segments and substructures of the human hand-arm. The characteristic frequencies were additionally assessed from conveyed reactions under symphonious excitation. The Model results were contrasted and characteristic frequencies got from measured biodynamic reactions, by operational modular examination [4].

Human head's biomechanical reactions to vibrations are frequently portrayed as far as arrived at the midpoint of exchange elements of impedance or evident mass acquired in trials. These intrusive analyses on people are restricted by ethic concerns, as well as the unwavering quality of the poll results which differ with subjectivity of tried volunteers. In addition, averaging strategies in test information estimations includes the danger of distinguishing unnatural vibration qualities. Modular examination, which holds for all exchange capacities, can be utilized as an option strategy for portraying biomechanical reactions of human head and for correlation of modular parameters, for example, normal frequencies and modular shapes, with exploratory information. Modular examination utilizing limited component technique (FEM) serves to give knowledge in comprehension the conduct of the human body and anticipating the result of presentation to vibrations [5].

The biodynamic reaction of the hand-arm framework is one of the establishments for understanding and evaluating hand-transmitted vibration exposures. The reproduction of the reaction can upgrade the comprehension of the reaction. It might likewise improve the outlines and investigations of controlled hand instruments and against vibration gadgets using vibration testing machine shown in fig(1) . While recreations of the biodynamic reactions appropriated at the fingers and palm of the hand along the lower arm heading or the bearing of the hand have been accounted for, the disseminated reactions in the other two orthogonal bearings have not been reenacted [6].

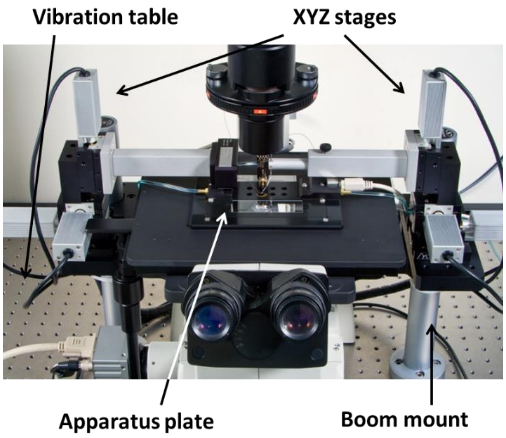

Fig. (1) Vibration Testing

1.1 The Impact of Vibrations

Most worldwide associations demonstrate hurtful to the effect of vibration on the human body, for example, • Affected interim home grown connections: as it is for the whole body vibration serious effect on the spine and sensory system to the specialist introduction to vibration ranges between 4-5 Hz. Vibrating influenced inner organs on the whole body to shake ranges between 4-5Hz skull is influenced when access to the vibration between 20 - 30Hz, which may bring about the capacity to center and great vision. Vascular issue: This happens broadly for specialists who hold the vibrating device, particularly if the period surpasses got gadget for more than15 minutes without rest. Influenced bones: where vibration influences the bones and joints and debilitate, particularly bones of the joint with introduction to shake hands [7].

1.2 Addressing the effect of vibrations

Entire body vibration can bring about weariness, a sleeping disorder, stomach issues, cerebral pains and "vibration" soon after or amid presentation.

Manifestations like those that numerous individuals encounter after a long auto or a watercraft trip. After day by day introduction over various years, entire body vibration can influence the whole body as shown in fig.(2), bringing about various wellbeing issue. Ocean, and air vehicles, or area reason the proposition of the illness when presented to vibration happens in the measure of 0.1 to 0.6 Hz recurrence range. Investigations of transport drivers, trucks were found that word related introduction to vibration of the entire body, and may have added to various intestinal circulatory, respiratory and muscle issue and back [8].

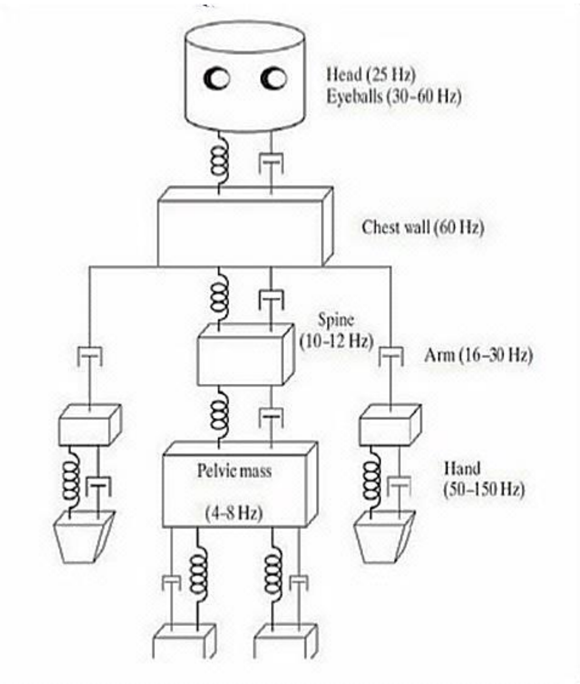

Fig.(2) Whole body

2. Theoretical Analysis

2.1 Human body

The human body and a vibratory model used to study the response of this system when subjected to vertical excitations are shown in Fig. (3). the model has many masses, spring, and damping elements. many independent displacement variables are needed to describe the motion of this system.

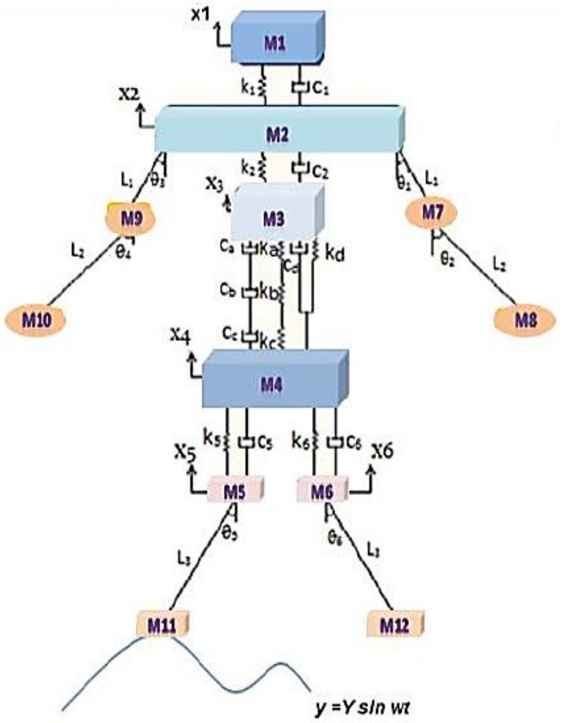

Fig. (3) Vibratory model of a human

2.2 Analysis the Model

The general equations modeling the multi-degree system of the human body stated as:

The first equation of motion of mass (m_1)

$$m_1\ddot{X}_1 + C_1(\dot{X}_1 - \dot{X}_2) + K_1(X_1 - X_2) = 0$$

Rearranging

$$m_1\ddot{X}_1 + C_1\dot{X}_1 - C_1\dot{X}_2 + K_1X_1 - K_1X_2 = 0 \text{ --}(1)$$

The second equation of motion of mass (m_2)

$$m_2\ddot{X}_1 + C_1(\dot{X}_2 - \dot{X}_1) + C_2(\dot{X}_2 - \dot{X}_3) + K_1(X_2 - X_1) + K_2(X_2 - X_3) = 0$$

Rearranging

$$m_2\ddot{X}_2 - C_1\dot{X}_1 + (C_1 + C_2)\dot{X}_2 - C_2\dot{X}_3 - K_1X_1 + (K_1 + K_2)X_2 - K_2X_3 = 0 \text{------}(2)$$

The third equation of motion of mass (m_3)

$$m_3\ddot{X}_3 + C_2(\dot{X}_3 - \dot{X}_4) + C_7(\dot{X}_3 - \dot{X}_4) + K_2(X_3 - X_2) + K_3(X_3 - X_4) = 0$$

Rearranging

$$m_3\ddot{X}_3 + (C_2 + C_3)\dot{X}_3 - C_2\dot{X}_2 - C_3\dot{X}_4 + (K_2 + K_3)X_3 - K_2X_2 - K_3X_4 = 0 \text{-----}(3)$$

$$\frac{1}{K_3} = \frac{1}{Ka} + \frac{1}{K_b} + \frac{1}{Kc} + K_d$$

$$K_3 = \frac{k_a\, k_b\, k_c}{k_b\, k_c + k_a\, k_c + k_a\, k_b + k_a\, k_b\, k_a\, k_b\, k_d}$$

and

$$\frac{1}{C_3} = \frac{1}{Ca} + \frac{1}{Cb} + \frac{1}{Cc} + C_d$$

$$C_3 = \frac{c_a\, c_b\, c_c}{c_b\, c_c + c_a\, c_c + c_a\, c_b + c_a\, c_b\, c_a\, c_b\, c_d}$$

The fourth equation of motion of mass (m_4)

$$m_4\ddot{X}_4 + C_5(\dot{X}_4 - \dot{X}_5) + C_6(\dot{X}_4 - \dot{X}_6) + C_3(\dot{X}_4 - \dot{X}_3) + K_5(X_4 - X_5) + K_6(X_4 - X_6) + K_3(X_4 - X_3) = 0$$

Rearranging

$$m_4\ddot{X}_4 + (C_5 + C_6 + C_3)\dot{X}_4 - C_5\dot{X}_5 - C_6\dot{X}_6 - C_3\dot{X}_3 + (K_5 + K_6 + K_3)X_4 - K_5X_5 - K_6X_6 - K_3X_3 = 0 \text{ --}(4)$$

The fifth equation of motion of mass (m_5)

$$m_5\ddot{X}_5 + C_5(\dot{X}_5 - \dot{X}_4) + K_5(X_5 - X_4) = 0$$

Rearranging

$m_5\ddot{X}_5 - C_5\dot{X}_4 + C_5\dot{X}_5 - K_5X_4 - K_5X_5 = 0$ --(5)

The sixth equation of motion of mass (m_6)

$$m_6\ddot{X}_6 + C_6(\dot{X}_6 - \dot{X}_4) + K_6(X_6 - X_4) = 0$$

Rearranging

$m_6\ddot{X}_6 - C_6\dot{X}_4 + C_6\dot{X}_6 - K_6X_4 + K_6X_6 = 0$ -------------------------------------(6)

The seventh equation of motion for the mass (m7) assume the arm is a bar.

Lagrange's equation is an entirely scalar procedure, starting from the scalar quantities of kinetic energy, potential energy, and work expressed in terms of generalized coordinates [8]. It is presented here as:

$$\frac{d}{dt}\left(\frac{\partial K.E}{\partial q_i}\right) + \frac{\partial P.E}{\partial q_i} + \frac{\partial K.E}{\partial \dot{q}_i} + \frac{\partial D.E}{\partial \dot{q}_\iota} = 0$$

Rearranging

$$K.E = \frac{1}{2}m_7(V_1^2 + V_2^2) + \frac{1}{2}J_7\dot{\theta}_1^2 + \frac{1}{2}J_8\dot{\theta}_2^2$$

$$K.E = \frac{1}{2}m_7(\, a_1^2 + \dot{\theta}_1^2) + \frac{1}{2}m_8\left(L_1\dot{\theta}_1 + a_2\dot{\theta}_2\right)^2$$

$$P.E = m_7 g a_1(1 - cos\theta_1) + m_8 g\{a_2(1 - cos\theta_2) + L_1(1 - cos\theta_1)\}$$

$$D.E = 0$$

at $q_i = \theta_1$ $\qquad$ $q_i = \theta_2$

$$m_8 a_2 L_1\ddot{\theta}_1 + a_1^2 m_7\ddot{\theta}_1 + m_8 L_1^2\ddot{\theta}_1 + J_1\ddot{\theta}_1 + m_7 g a_1\theta_1 + m_8 g L_1\theta_1 = 0$$

Rearranging

$(m_8L_1^2 + a_2^2 m_7 + J_1)\ddot{\theta}_1 + m_8 a_2 L_2\ddot{\theta}_2 + (m_7 g a_1 + m_8 g L_1)\theta_1 = 0$ ---------------(7)

The eighth equation of motion of mass (m_8)

$$m_8 a_2 L_1\ddot{\theta}_1 + a_2^2 m_8\ddot{\theta}_2 + J_2\ddot{\theta}_2 + m_8 g a_2\theta_2 = 0$$

Rearranging

$(a_2^2 m_8 + J_2)\ddot{\theta}_2 + m_8 a_2 L_1\ddot{\theta}_1 + m_8 g a_2\theta_2 = 0$ --(8)

The ninth equation of motion of mass (m_9) assume the arm is bar from Lagrange's equation

$$K.E = \frac{1}{2}m_9(V_1^2 + V_2^2) + \frac{1}{2}J_9\dot{\theta}_3^2 + \frac{1}{2}J_{10}\dot{\theta}_4^2$$

$$P.E = m_9 g a_1(1 - cos\theta_3) + m_{10} g\{a_2(1 - cos\theta_4) + L_1(1 - cos\theta_9)\}$$

let $q_i = \theta_3$ $\qquad$ $q_i = \theta_2$

$$m_9 a_1^2\ddot{\theta}_3 + m_{10}L_1^2\ddot{\theta}_3 + m_{10}a_1L_1\ddot{\theta}_4 + J_3\ddot{\theta}_3 + m_9 g a_1\theta_3 + m_{10} g L_1\theta_3 = 0$$

Rearranging

$(m_{10}L_1^2 + a_2^2 m_9 + J_3)\ddot{\theta}_3 + m_{10}a_1L_1\ddot{\theta}_4 + (m_9 g a_1 + m_{10} g L_1)\theta_3 = 0$ ---------(9)

at $q_i = \theta_4$ $\qquad$ $q_{i=}\theta_5$

the tenth equation of motion of mass (m_{10})

$$m_{10}a_2L_1\ddot{\theta}_5 + a_2^2 m_{10}\ddot{\theta}_2 + J_4\ddot{\theta}_4 + m_{10} g a_2\theta_4 = 0$$

Rearranging

$m_{10}a_2L_1\ddot{\theta}_5 + (a_2^2 m_{10} + J_4)\ddot{\theta}_4 + m_{10} g a_2\theta_4 = 0$ ------------------------------(10)

the eleventh equation of motion of mass (m_{11})

$m_{11}L_3^2\ddot{\theta}_5 + m_{11} g L_3\theta_5 = Y \sin\omega t$ --(11)

the twelfth equation of motion of mass (m12)

$m_{12}L_3^2\ddot{\theta}_6 + m_{12} g L_3\theta_6 = 0$ --(12)

Putti ng equation (1 -12) in matrix from of (12*12) follows as :

$$M_{ij}\{\ddot{q}(t)\} + C_{ij}\{\dot{q}(t)\} + K_{ij}\{q(t)\} = \{Q(t)\}$$

$$\begin{vmatrix}
m_1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & m_2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & m_3 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & m_4 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & m_5 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & m_6 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & m_8 l_1^2 + m_7 a_2^2 + j_1 & m_8 a_2 l_2^2 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & m_8 a_2 l_1 & m_8 a_2^2 + j_2 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & m_{10} l_1 + m_9 a_2 + j_3 & m_{10} l_1 a_1 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & m_{10} l_1 a_2 & m_{12} l_2^2 + m_{12} g l_4 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & m_{11} l_2^2 + m_{11} g l_2 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & m_{12} l_2^2 + m_{12} g l_2
\end{vmatrix}$$

$$
\begin{Bmatrix} \ddot{x}1 \\ \ddot{x}2 \\ \ddot{x}3 \\ \ddot{x}4 \\ \ddot{x}5 \\ \ddot{x}6 \\ \ddot{\theta}1 \\ \ddot{\theta}2 \\ \ddot{\theta}3 \\ \ddot{\theta}4 \\ \ddot{\theta}5 \\ \ddot{\theta}6 \end{Bmatrix}
+
\begin{vmatrix}
c_1 & -c_1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & c_1+c_2 & -c_2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & -c_2 & c_1+c_3 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & -c_3 & c_1+c_3 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & c_3+c_5+c_6 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & -c_5 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & c_5 & -c_6 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & c_6 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0
\end{vmatrix}
$$

$$
\begin{Bmatrix} \dot{x}1 \\ \dot{x}2 \\ \dot{x}3 \\ \dot{x}4 \\ \dot{x}5 \\ \dot{x}6 \\ \dot{\theta}1 \\ \dot{\theta}2 \\ \dot{\theta}3 \\ \dot{\theta}4 \\ \dot{\theta}5 \\ \dot{\theta}6 \end{Bmatrix}
+
\begin{vmatrix}
k_1 & -k_1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
-k_1 & k_1+k_2 & -k_2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & -k_2 & k_2+k_3 & -k_3 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & -k_3 & k_3+k_5+k_6 & -k_5 & -k_5 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & -k_5 & k_5 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & k_6 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & m_7 g a_1 + m_8 g l_1 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & m_8 g a_2 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & m_9 g a_2 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & m_{10} g a_2 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & m_{11} g a_2 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & m_{12} g a_2
\end{vmatrix}
$$

$$
\begin{Bmatrix} x1 \\ x2 \\ x3 \\ x4 \\ x5 \\ x6 \\ \theta 1 \\ \theta 2 \\ \theta 3 \\ \theta 4 \\ \theta 5 \\ \theta 6 \end{Bmatrix}
=
\begin{Bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ Y \end{Bmatrix}
$$

The following tables gives the various values of the masses, damping constants and Stiffness and spring element for human body that modeled in this study [11].

Table 1 Value of mass for human body model

Mass	Value (kg)	Length cm	Width cm
m_1	3.310	19	15.57
m_2	9.39	21	146
m_3	17.067	15	25.5
m_4	6.491	20	35.43
m_5	1.5	30	8.65
m_6	1.5	30	8.65
m_7	2.687	21	6.5
m_8	2.720	35	7.84
m_9	2.687	21	6.5
m_{10}	2.720	35	7.84
m_{11}	1.139	45	9.35
m_{12}	1.139	45	9.35

Table **2** Damping constants of the Model

Damping constants	Value N.s/m	Length cm
c_1	4.80	9
c_2	6.50	6
c_3	3.30	20
c_5	699.71	30
c_6	699.71	30

Table **3** Stiffness of the spring

Spring elements	Value K N/m	Length cm
K_1	680.5	9
K_2	584.2	6
K_3	152.1	20
K_5	130.5	30
K_6	130.5	30

$$\begin{Bmatrix} \dot{x}1 \\ \dot{x}2 \\ \dot{x}3 \\ \dot{x}4 \\ \dot{x}5 \\ \dot{x}6 \\ \dot{\theta}1 \\ \dot{\theta}2 \\ \dot{\theta}3 \\ \dot{\theta}4 \\ \dot{\theta}5 \\ \dot{\theta}6 \end{Bmatrix} + \begin{vmatrix} 0.68 & -0.68 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -0.68 & 1.264 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & -0.584 & 1.264 & 0.73 & -0.152 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -0.584 & -0.152 & 0.413 & 0.1305 & 0.1305 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0.1305 & 0.1305 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0.1305 & 0 & 0.1305 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1549 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 6.84 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 15.84 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 6.84 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 5.16 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 5.16 \end{vmatrix}$$

$$\begin{Bmatrix} x1 \\ x2 \\ x3 \\ x4 \\ x5 \\ x6 \\ \theta 1 \\ \theta 2 \\ \theta 3 \\ \theta 4 \\ \theta 5 \\ \theta 6 \end{Bmatrix} = \begin{Bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ Y \end{Bmatrix}$$

2.3 Mode Shapes

The equation of mode depended upon the matrix of stiffness, the stiffness coefficient and determinate as:

$$\varphi_{ij} = K_{ij}{}^{-1} = \frac{adjK_{ij}}{|K_{ij}|}$$

$$adj\ K_{ij} = \left[K_{ij}{}^{c}\right]^{T} / |K_{ij}|$$

When i=1, 12 j=1, 12

The natural frequencies of the system is:

$$\omega_{ij}^2 = \varphi_{ij}\, K_{ij}\, \varphi_{ij}{}^{T} / \varphi_{ij}\, K_{ij}\, \varphi_{ij}{}^{T}$$

Where $i = 1, 12 \quad and \qquad j = 1, 12$

2.4 Response of the human body

$$q_i(t) = \sum_{j=1}^{12} A_i\, \varphi_{ij}\ \sin(\omega_i t + \psi_i)$$

Where $i = 1, 12 \quad and \qquad j = 1, 12$

A_j , ψ_j are the arbitrary constant and phase analysis can be determined from the initial condition.

$q_i(0)$, $i = 1,12$

$\dot{q}_i(0)$, $i= 1,12$

$\ddot{q}_i(0)$, $i= 1,12$

3. Results and Discussion

This study presents the response of human to external vibration methodology of solution computer process used to avoid the risks. The human body is represented as spring –mass-damper system. the system then modeled and solved analytically by obtain the equations of motion used Newton second law taking into account the inertia forces , spring forces and the damping forces, the external force is a sinusoidal function initiated by the leg of the human during the motion . then simplify, according Maxwell theorem, which give the prediction the motion of the model to obtain the natural frequencies and the principle modes (Eigen vectors) of the motion, the cumulative responses of the model results from the excitation applied on the human model to know the effect of every part of the human body under the external excitation to predict the comfort ability of human also determine the natural frequencies and absorber the vibration by the springs and dampers according to standards data to maintain the human body at its natural case without any undesirable effects.

The motion of the human body was studied using mathematical equation of matlab program v7.60234 as shown in Fig. (4) where the human as points and the response it of during the motion in specified time. Fig. (5) shows Acceleration, velocity and displacement of the model and Fig. (6) displays the displacement velocity and acceleration for leg of the excited by the external force which is the initial execration and the Fig(7) represent the effect of vibration on the arms, selecting this two parts cause they are the higher affecting to vibration . Where these two parts are the higher sensitize to the motion and any risk or absence during the natural frequencies make the human is under unbalancing and in natural case. To avoid the unpleasant effect they present the human to do his daily jobs in natural manor and less power.

The model studied in this paper consist of 6-part translation motion and having 6-part rotational motion modeled as 6- pendulums for human model having 186 cm long, the other dimension such as the value of mass, length of the each part shown in Table (1) to maintain the balancing of these masses using spring, dampers with different values as every part and how much subjected to the vibration and the external forces as sinusoidal function take 1 Hz.The matlab program is used to study the mechanical system the Sim Mechanics order. the system studied in this paper is the human body which masses, springs and dampers subjected to external force (sinusoidal function).the order of matlab program are taken from the block library .the model of the human body is used to excited by these orders with in the machine environment , the ground is the reference point is the point where the other order dimension are initiated for the human body system represented as masses, springs and dampers beside to the sensor used the sensing the motion of the system (joint sensor) also an order for changing the motion by using two prismatic orders to change the liner motion about y-axis and cylindrical for translational-Rotational motion to change the arm motion a scope order is used to present the simplified description of the model Move as in Fig. (7) and (8) human or affected the system represented by the displacement and acceleration which are resulted from the external force on the human body in the initial motion case represented by the sin wave which can be sensed by adding the body sensor.

4. Conclusion

This paper present an exploratory examination of the human body influenced via compelled vibration identifies with by sinusoidal limit of the way that it gives a explanation of the weakness or response to the human body enhanced and more correct and that the representation of the body structure vibrations consider the dynamic development to any human body, this investigation is key: The showing of the human body for the evaluation of the vibration risk and grasp the gauges normal modes. To keep away from hurting the safety of the human body most subjected to vibrations, particularly in the down to business field to supports and fasting up the strategy of investigation for occurrences of disease by professionals to know the conventional scope for each bit of the gathering of frequencies coming to fruition in light of vibrations (which is described as shakings or vibrations issued by the machine arranged close from anyone) and that has been figured by ways which identify with by mechanical structures in associated outlining. Gives specialists fashioners to arrange, amassing and period of gadgets or contraptions that made any kind of vibrations dangerous to the people who are in contact with them, especially in examination focuses and mechanical offices that are created by estimations convey less measure of possible adverse results for the human body to give a pleasant space.

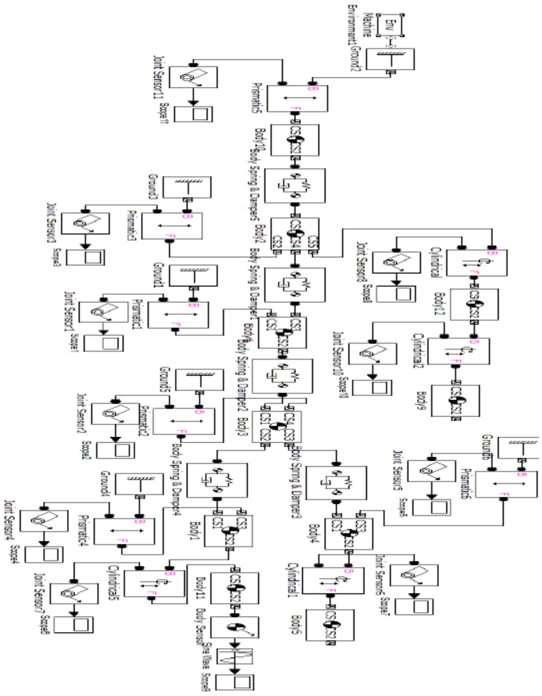

Fig. (4) Flow chart of main program

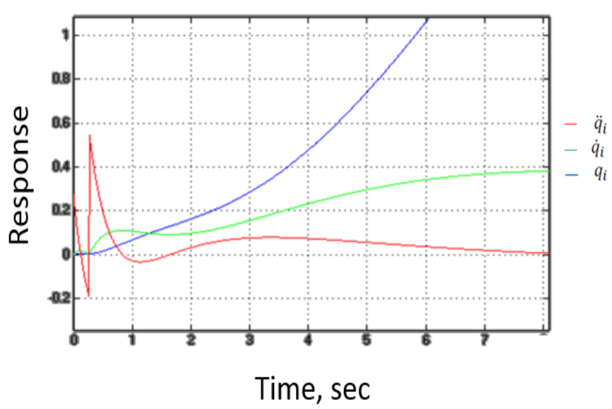

Fig. (5) Acceleration, velocity and displacement of the model

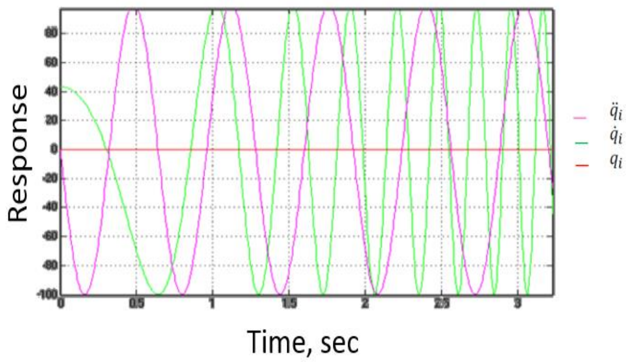

Fig (6) Effect of external force on the leg of the human body

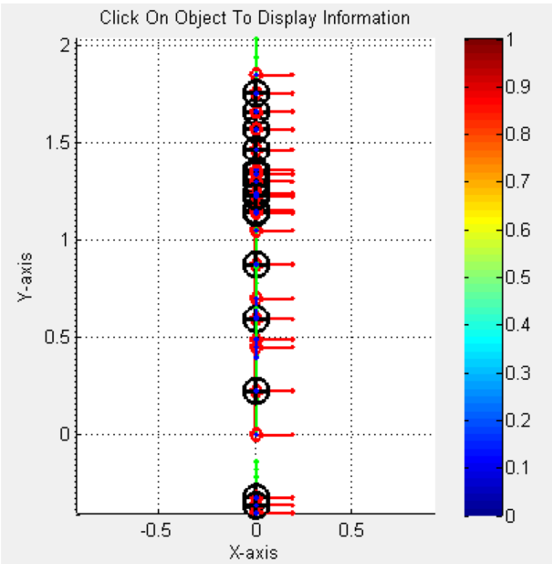

Fig. (7) Simplified description of the model

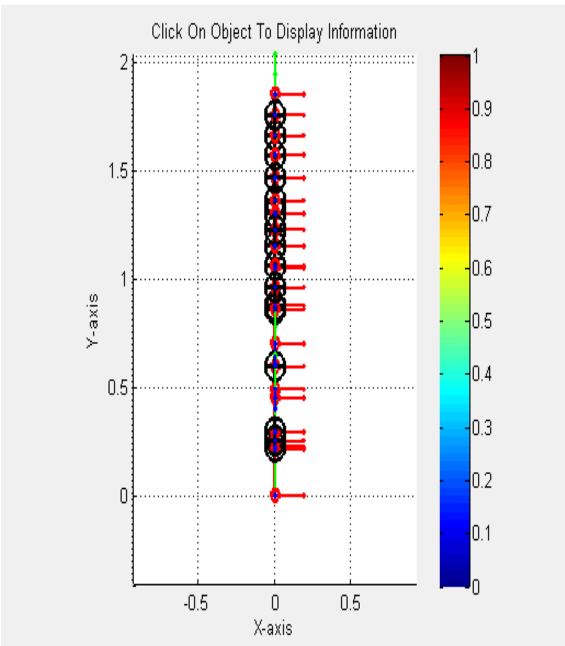

Fig. (8) Simplified description of the model during a certain share

Nomenclature

A	Variables	…
C	Damping elements	N.s/m
K	Stiffness matrix	N/m
Y	Force applied to the system	N/m
ϕ_{ij}	Mode shape	…
K^{c^T}	Cofactor transpose of the stiffness matrix	…
${\phi_{ij}}^T$	Transpose of the mode shape matrix	…
ω	Natural frequency	rad/s
$q(t)$	Response of the system	mm
m	Mass	kg
ψ	Phase angle	…

References

[1] Shawnp.MC, 2006, published and presented, hunting to Beach C A, Junly

[2] Bazil Basri and Michael J. Griffin, human Factor Research unite institute of sound and vibration Research, University of south amp ton, So171SB. .

[3] Proceedings of the international Multi Conference of engineers and computer scientists, Hong Kong, 2012, March, Vol II.

[4] Donald R. Detersor and Takafumi Asaki, 2012, proceeded of the 4th American conference on Human vibration, University of Connecticut Health Center Farmington, Connecticut.U.S.A., June.

[5] Dr Wilf Archer, Whole-body vibration, a guide to the injuries and illnesses related to this complaint, UK, 2001

[6] AMERICAN CONFERENCE ONHUMAN VIBRATION, Proceedings, June, 2008

[7] Balakumar Balachandran , Edward B. Magad, vibration second Edition.

[8] William T. Thomson, theory of vibration with application.

[9] Mayank Mishra, 2008, evaluation of damping coefficients of a vibratory model of the human body, Thapar University, Patiala-147004.

.

[7] M. I. Hasan, "Investigation of flow and heat transfer characteristics in micro pin fin heat sink with nanofluid", *J. Applied thermal engineering*,2014, 63, 598.

[8] Nawras A. A, "Heat Transfer Enhancement in a Uniformly Heated Tube Using nanofluids", University of Babylon , thesis for the degree of Master science in Mechanical engineering, (2014).

[9] H. H. Ting, S. S.Huo, "Investigation of laminar convective heat transfer for Al2O3-water nanofluids flowing through a square cross-section duct with a constant heat flux", *J. Materials*, 2015, 8, 5321.

[10] Z K. Kadhim, M S. Kassim, A Y.Abdul Hassan, "Effect of (MgO) nanofluid on heat transfer characteristics for integral finned tube heat exchanger", *J. Mechanical Engineering and Technology (IJEMT)*, 2016, 7, 11.